# APPENDIX O

# VEHICLE HARDENING

As the nature of conflict changes, so does the threat to logistics units. War and certain other operations--especially peacekeeping or peacemaking--place renewed emphasis on convoy security and reinforce lessons learned in Vietnam.

Current threats include the use of command-detonated and pressure-sensitive mines placed on, above, or along the shoulders of roads traveled by military vehicles and the ambushing of convoys and harassment with sniper fire. These methods of disrupting military operations are highly effective, cheap, require limited time and labor, are easy to coordinate, and can be accomplished by an unsophisticated enemy.

To counter these threats, motor transport units may be provided with security forces and supporting arms firepower. Also, special vehicle-hardening techniques using sandbags and other improvised material have proved successful in protecting convoy personnel, equipment, and cargo. This appendix describes these techniques. Although effective, vehicle-hardening techniques must be tailored to fit the specific environment in which the motor transport units are operating.

**O-1. HARDENED VEHICLES**. A hardened vehicle is made less vulnerable to the effects of explosives and small arms fire by adding sandbags, armor plating, ballistic glass, and other protective devices. Hardening may make certain vehicle components and cargo less vulnerable. Its primary purpose, however, is to protect the truck's occupants. The protection afforded is significant and often means the difference between injury and death.

The vehicle hardening techniques described here include locally fabricated (improvised) armor kits and sandbags. When an enemy threat exists, consider the following factors in determining the method and extent of vehicle hardening:

- *Flexibility*. Harden vehicles to provide the degree of protection required while maintaining maximum flexibility in vehicle use. Harden the cargo beds of vehicles carrying troops with sandbags. Beds of vehicles carrying cargo are not normally hardened (depending on the cargo).
- *Weight*. All vehicle hardening adds weight to the vehicle. One effect of added weight is to reduce proportionally the amount of cargo that can be carried. Another potential effect is added vehicle maintenance and durability problems. Consider the vehicle's payload capacity when deciding the extent of hardening.
- *Availability*. If it is necessary or desirable to fabricate armor kits, consider the availability of suitable materials and the time needed to complete the project.
- *Types of roads*. To some extent, the roads traveled by motor transport unit vehicles can affect the protection required. Hardtop roads, for example, generally present less hazard from mines than dirt roads. However, do not discount the possibility of ambush along any route. Consult the S2 for the most current information on the situation.

- *Maintenance*. Vehicle hardening normally increases the amount of vehicle maintenance needed and can cause mechanical or structural damage. The sandbags themselves, when used to

harden vehicles, also require periodic removal and replacement. If too much weight is added to the vehicle, it may reduce the vehicle's mobility and operational capabilities.

During Vietnam, the Army had three nonremovable armor kits for hardening 1/4-, 2 1/2-, and 5-ton trucks. These kits were later deleted from the inventory. Although no kits are currently available through the Army's supply system, several projects are under way to develop armor plating for use in hostile environments.

**O-2. SANDBAGS**. Sandbags are effective in reducing the effects of blasts, preventing fire from reaching the driver, and providing protection from small arms fire and fragmentation. Sandbags are usually readily available and do not permanently impair the flexibility of vehicles. Sandbags can easily be added or removed from the vehicle as the situation dictates. One drawback to using sandbags is that their weight limits the vehicle's capability to haul cargo.

All vehicles must be properly maintained according to the operator's -10 TM. Use the procedures below to prepare vehicles for convoy operations.

a. **Cab**. Experience shows that using sandbags to harden vehicle cabs for protection against mine blasts saves lives (Figure O-1). Normally, the cabs of all vehicles subject to detonating mines are hardened. Certain cautions, however, must always be observed. Sandbags should be placed so that they--

- Do not restrict the movement of foot pedals, levers, or controls.
- Do not interfere with the normal functions performed by the driver.
- Do not restrict driver vision.

To reduce the sandblast effect when a mine is detonated near the vehicle, various materials may be placed on top of the floorboard sandbags (such as rubber mats, light metal plates, plywood, or scraps of runway membrane material). Wetting down the sandbags is also effective but contributes to deterioration of the metal.

To properly prepare the vehicle cab, double-stack sandbags under the passenger seat and on the cab floor. Stack the sandbags two high under the driver's seat; in some vehicles this may not be possible. Remove the tools from the BII storage compartment and place them inside the bed. Place sandbags in the storage compartment to give the driver required protection. As an added precaution, place a heavy rubber or fiber mat over the sandbags. This reduces danger from fragments (such as stones, sand, and metal parts from the vehicle).

NOTES:
1. If the tools remain in the BII storage compartment and the vehicle detonates a mine, the tools may become secondary projectiles that can injure the driver. Also, if sandbags cannot be placed under the passenger seat because batteries are located there, then stack the sandbags on the seat. Never place sandbags directly on the batteries.
2. The cab of a 5-ton M923 cargo truck needs about 14 to 20 sandbags, while a 2 1/2-ton truck requires about 12 to 18 sandbags.

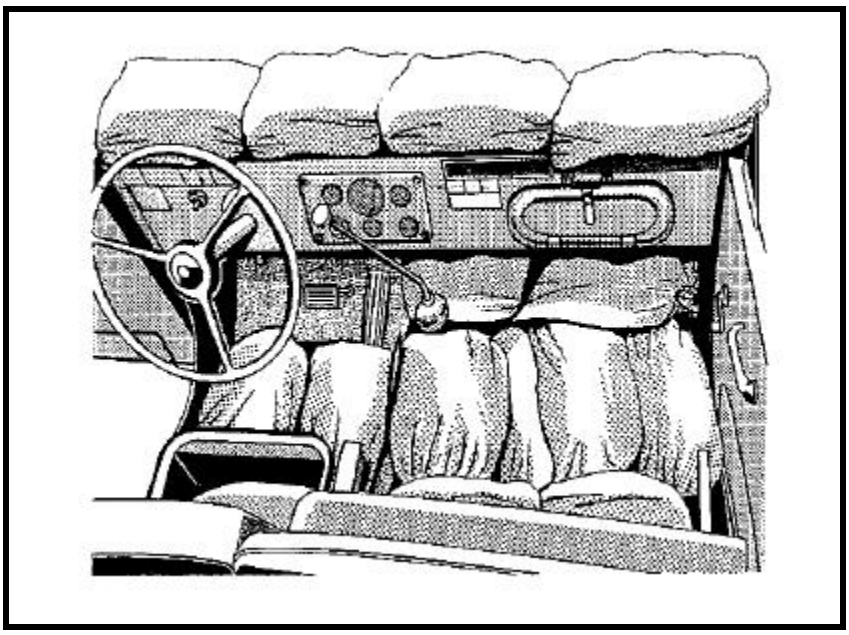


**Figure O-1. Proper placement of sandbags in the cab**

Attach to the doors locally fabricated 1/4- to 1/2-inch-high hardened, removable armor plates. (Use hooks to attach the steel plates to the window slots). Cover side windows and the front windshield with wire mesh to protect personnel from rocks and grenades. The convoy commander will decide whether to have windshields removed, lowered, or left in place. If the windshield interferes with the use of weapons and blackout operations and must be lowered, place a single layer of sandbags under the windshield, lower the windshield onto the bags, place a second layer of sandbags over the windshield, and then cover both with canvas (Figure O-2, page O-4). Placing sandbags under the windshield ensures that--

- Constant vibrations of the vehicle do not damage the windshield.
- Sand is not blown into the driver's face.
- Glass will not shatter and injure the driver and passenger.

NOTE: Leaving the windshield in place protects against heavy and driving rain, incoming grenades, and decapitation of personnel from wire stretched across the road.

b. **Cargo Bed**. Depending on the type of load, the cargo bed may or may not be hardened. For example, if troops are being transported, the bed needs to be hardened with a double layer of sandbags. The bags also need to be properly fitted to the contours of the vehicle. Stack the bags five high around the sides of the vehicle to add protection. To hold the sandbags in place, construct a support structure and place it inside the bed of the vehicle. This structure can be made by using four-by-fours on the corners and two-by-sixes in between (Figure O-3, pages O-4 and O-5).

NOTE: Caution must be taken to ensure that the sandbags do not exceed the allowable weight of the vehicle bed. Double stacking the sandbags increases the possibility of exceeding the vehicle's payload capacity. The mission, coupled with the enemy threat, must determine the extent of hardening (single- or double- layer sandbags). The bottom line is to ensure soldier safety.

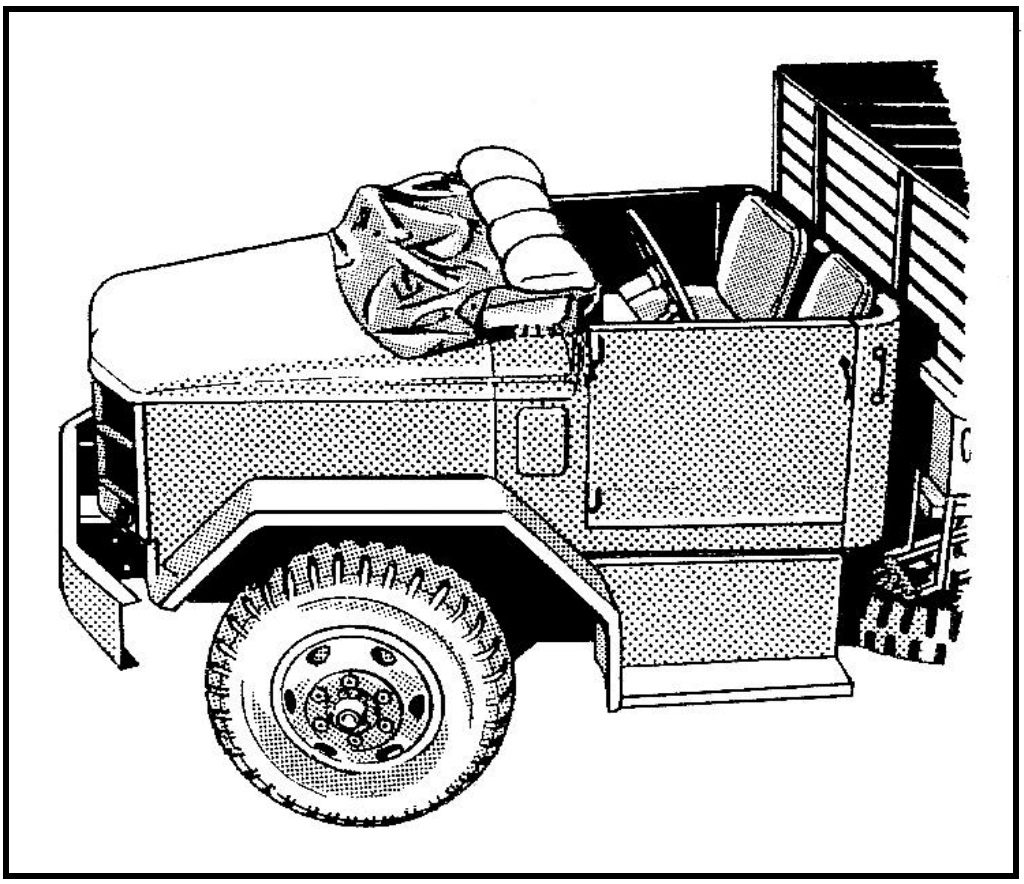


**Figure O-2. Proper placement of sandbags under the windshield**

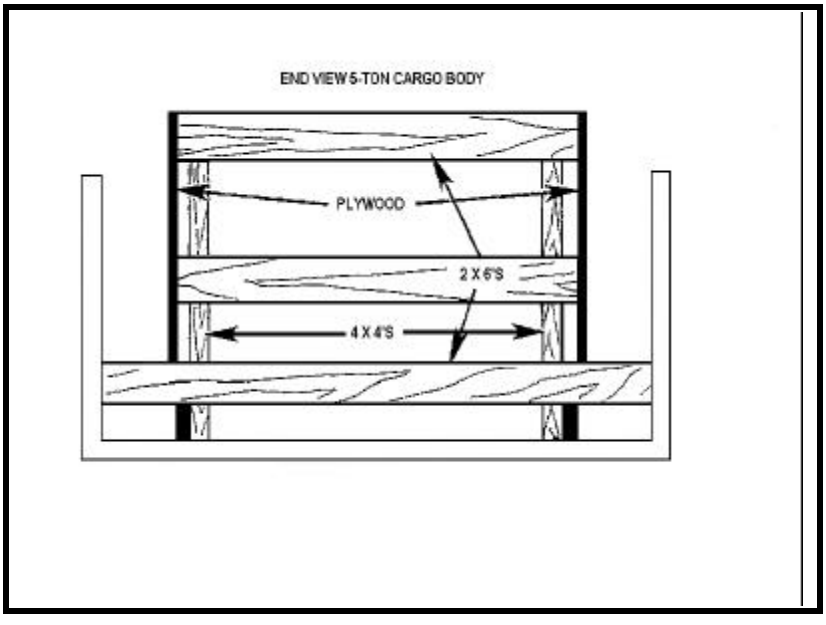



**Figure O-3. Support structure for the bed of the truck**

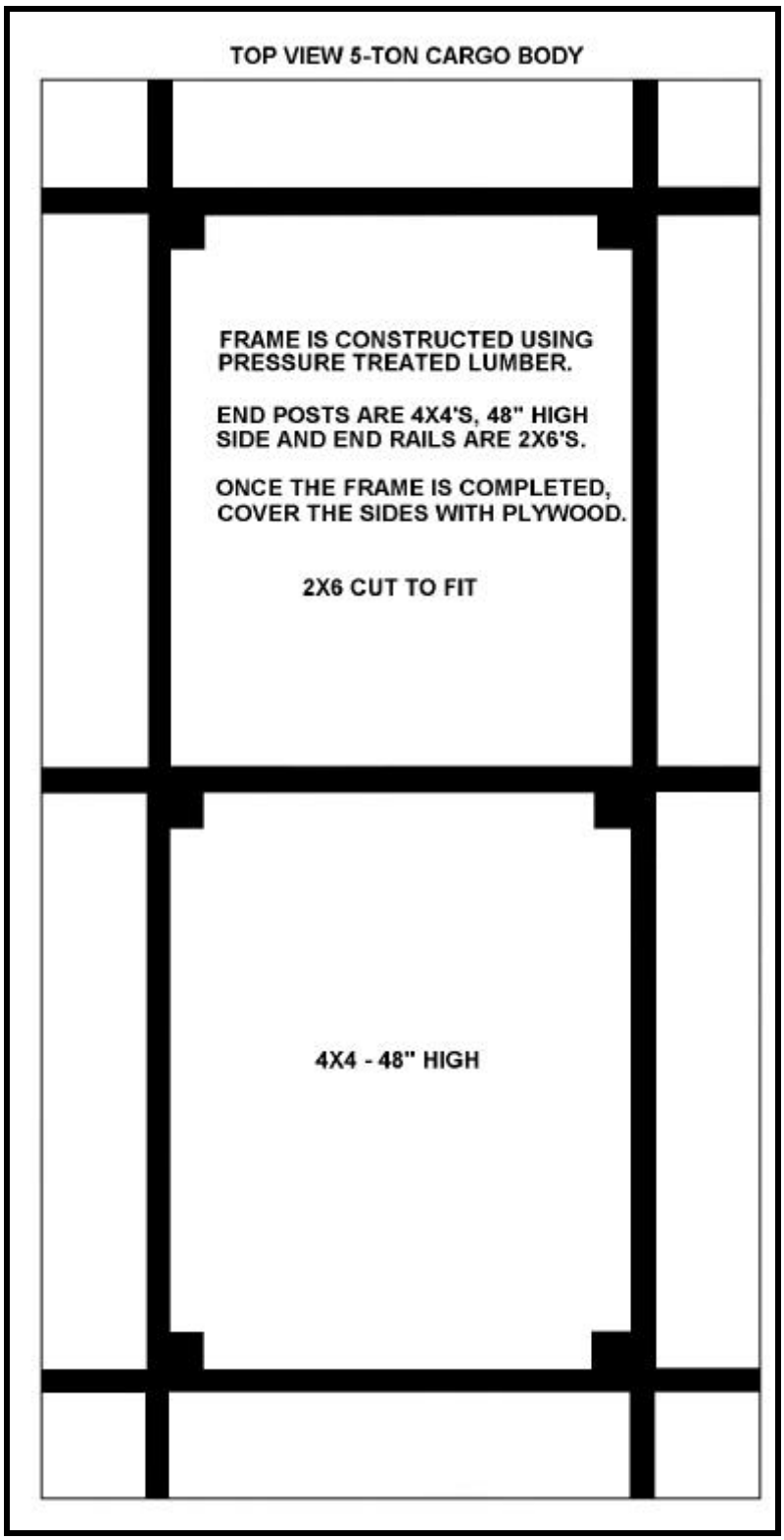



**Figure O-3. Support structure for the bed of the truck (continued)**

It takes about 226 sandbags (dry, weighing about 40 pounds each) to prepare the bed of a 5-ton, M923 cargo truck. Distribution is as follows: 86 on the floor bed (single layer); 5 high on each side (50 per side = 100 bags); 20 in the front; and 20 in the rear of the bed (Figure O-4).

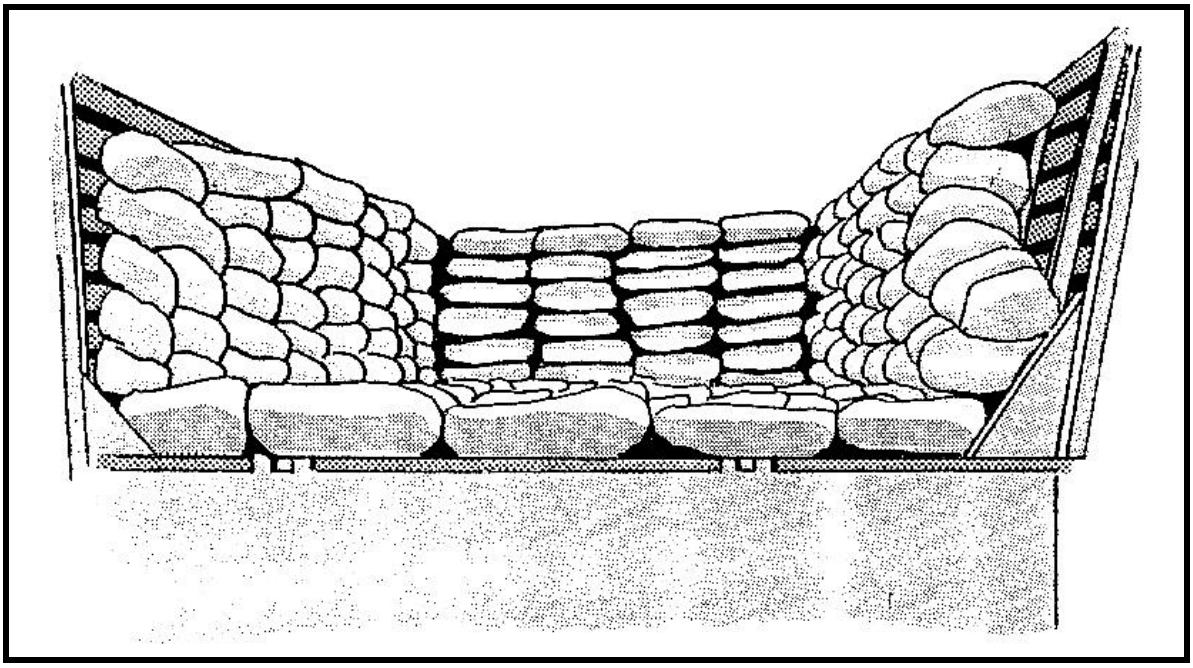


**Figure O-4. Sandbagged 5-ton M923 cargo truck**

c. **Fuel Tanks**. Protective plating around the fuel tank will lessen the damage to the fuel tank. It will also help to ensure that the fuel tank is not pierced, thus immobilizing the vehicle. This protective measure is especially critical when a vehicle is caught in the kill zone of an ambush. An alternative solution to this problem is to hook up a 5-gallon can of fuel in a safe location for use as an auxiliary fuel tank. This will allow the vehicle to travel a safe distance outside the kill zone if all the fuel is drained from a damaged fuel tank.

NOTES:
1. A 5-ton M923 cargo truck requires about five sandbags to provide top protection. Consider placing protective plating around the sides and bottom of the fuel tank to increase protection.
2. Older vehicles in the Army inventory may still be operating on MOGAS. If a tank filled with MOGAS is ruptured, the fuel may ignite and seriously burn operating personnel.
3. When putting sandbags or protective plating on or around the fuel tank, ensure that the hanger straps of the fuel tank do not crack or break.

**O-3. TARPAULINS AND CAB TOPS**. There are advantages and disadvantages to using canvas truck tops or tarpaulins, and these should be assessed. Advantages to keeping cargo covered include:

- Ensures that goods are not damaged by prevailing weather conditions.

- Denies intelligence information to the enemy concerning the type of cargo being transported.

Major disadvantages to installing truck tops or tarpaulins include:

- Required removal for loading and unloading operations.
- Interference with the driver's vision and assistant driver's ability to fire to the rear.

**O-4. MAINTENANCE OF HARDENED VEHICLES**. Hardening vehicles with armor plating places abnormal stresses on the vehicle that can result in early component failure. It is common for engine mounts, cab mount bushings, and bolts to loosen. For this reason, they should be checked, tightened, and replaced regularly. In the past the vehicle deadline rate for hardened vehicles was up to 20 percent greater than for nonhardened vehicles.

Sandbags become torn or punctured in day-to-day use. They also collect and hold water, causing metal surfaces to rust. Added maintenance is required to keep the sandbags in good condition and to prevent rust. Sandbags should be checked periodically and removed or replaced. When the sandbags are removed, the vehicle metal should be cleaned, painted (if necessary), and allowed to dry before the sandbags are replaced. Empty sandbags and ties should always be kept in the vehicle.

NOTE: When sandbags get wet, their weight increases significantly, thus putting added stress on the vehicle.

**O-5. FUTURE HARDENING MATERIALS**. The hardening materials described in this appendix are those currently available. Lighter, more durable materials are being developed, so the problems now associated with vehicle hardening may be alleviated in the future. Improvements will include: ballistic glass, redesigned seats, ceramic-faced composite steel doors, and armored deflective shields on the undercarriage of the vehicle (on wheel wells and under the cab).

**O-6. GUN TRUCKS**. Logistical convoys cannot always depend on military police support or added firepower. To provide more firepower for a convoy, units developed the gun truck. The purposes of a hardened gun truck are to--

- Provide a base of fire.
- Help counter enemy attacks.
- Increase survivability of the convoy.

The gun truck is equipped with a crew-served weapons system, preferably in a protective position. In Vietnam this principle worked well and provided convoys a means of self-defense.

Deploy the gun truck in the convoy where it can best provide the needed firepower. If adequate communications assets are available, they should be located with the gun truck and the convoy commander. This enables the convoy commander to call the gun truck forward when needed. (A predesignated signal is required to bring the gun truck forward and inform the crew-served weapon system personnel of the enemy location.) If communications assets are not adequate, pyrotechnics may be used to signal the gun truck to move forward.

The gun truck should not be pulled up right on top of the enemy location. The crew-served weapons on the gun truck can cover a significant distance. Therefore, the vehicle should be situated where it has a clear field of fire to engage the enemy with the maximum effective range of the weapon. If necessary and if available, multiple gun trucks can be used. When using multiple gun trucks in a convoy, overlapping fields of fire greatly increases the convoy's chance of survival.

NOTES:
1. Based on availability, types of weapon systems, and size of the convoy, the placement and number of gun trucks may vary. With company-size and larger convoys, a minimum of two gun trucks should be used to provide overlapping fire. One gun truck for every eight vehicles in the convoy is recommended.
2. Consider using the MK19 or M203 to penetrate prepared defensive positions since small arms fire may not be capable of destroying enemy positions.

Figure O-5 is an example of the gun truck used in Vietnam. It shows the armor plating used for the windshield and doors of the vehicle. It also depicts the layout of the weapon systems mounted on the vehicle with identified firing ports and specific areas of responsibility.

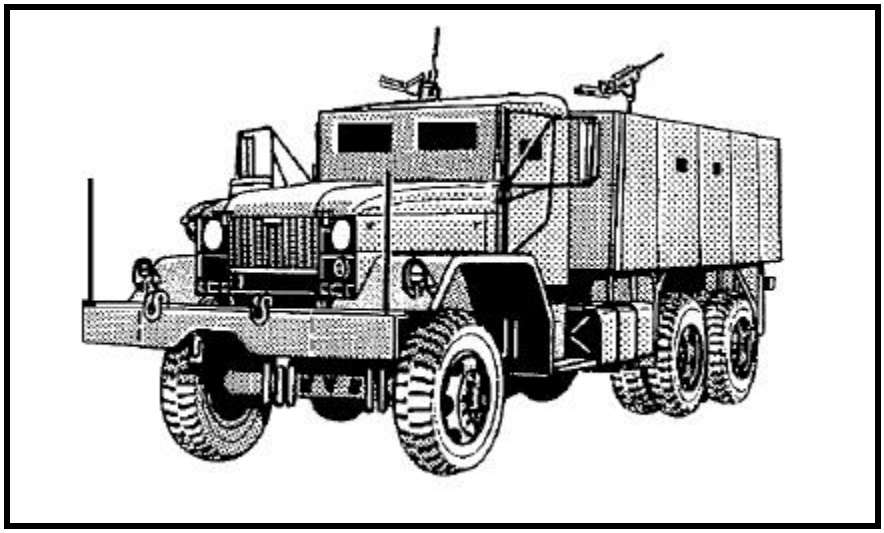
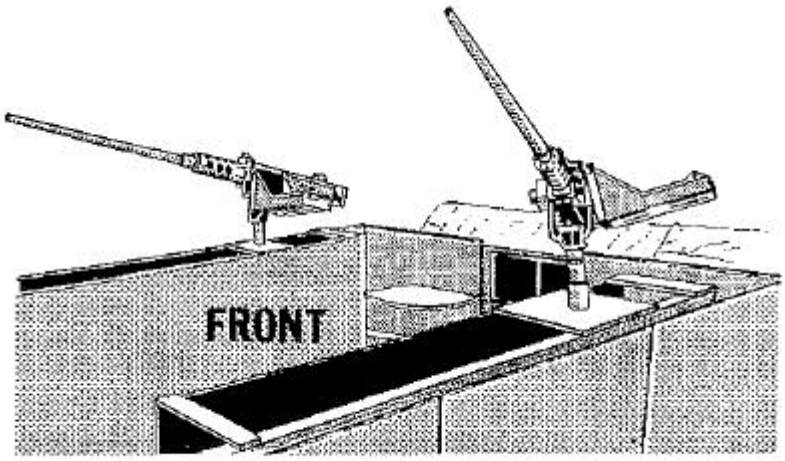


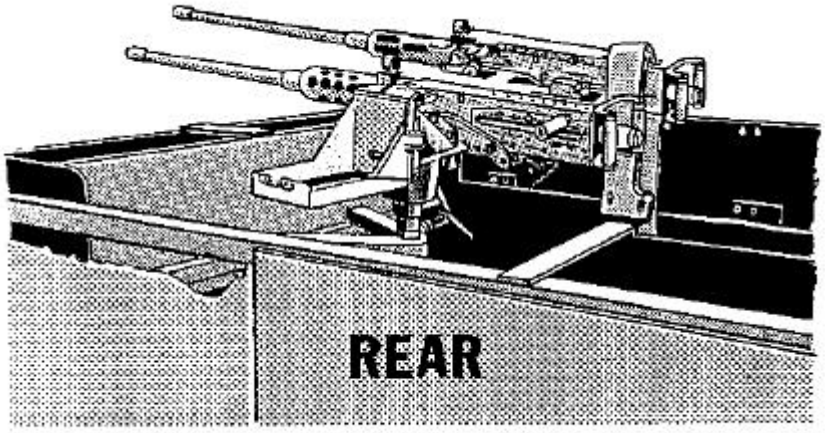
**Figure O-5. Gun truck used in Vietnam**

Figure O-6 shows how M2 machine guns were mounted on the gun truck using locally fabricated materials.

**O-7. BALLISTIC TEST RESULTS**. It is critical that the most protective material available be used to harden a vehicle. Ballistic tests show that sand is about twice as effective as clay in hardening vehicles. At a maximum velocity of 3,250 feet per second at a range of zero feet, it takes about .6 feet of sand and 1.2 feet of clay to stop a 5.56-mm round. At a maximum velocity of 2,750 feet per second, it takes about .9 feet of sand or 1.7 feet of clay to stop a 7.62-mm round. Finally, at the maximum velocity, it takes about 1.4 feet of sand or 2.6 feet of clay to stop a 50-caliber round. Using the most protective substance could mean the difference between life and death for our most precious resource--our soldiers.

Table O-1, pages O-10 and O-11, shows the results of mine tests conducted using a variety of C4 explosive charges. It offers insight to the devastating effects and damage that mines can cause.


FRONT


REAR

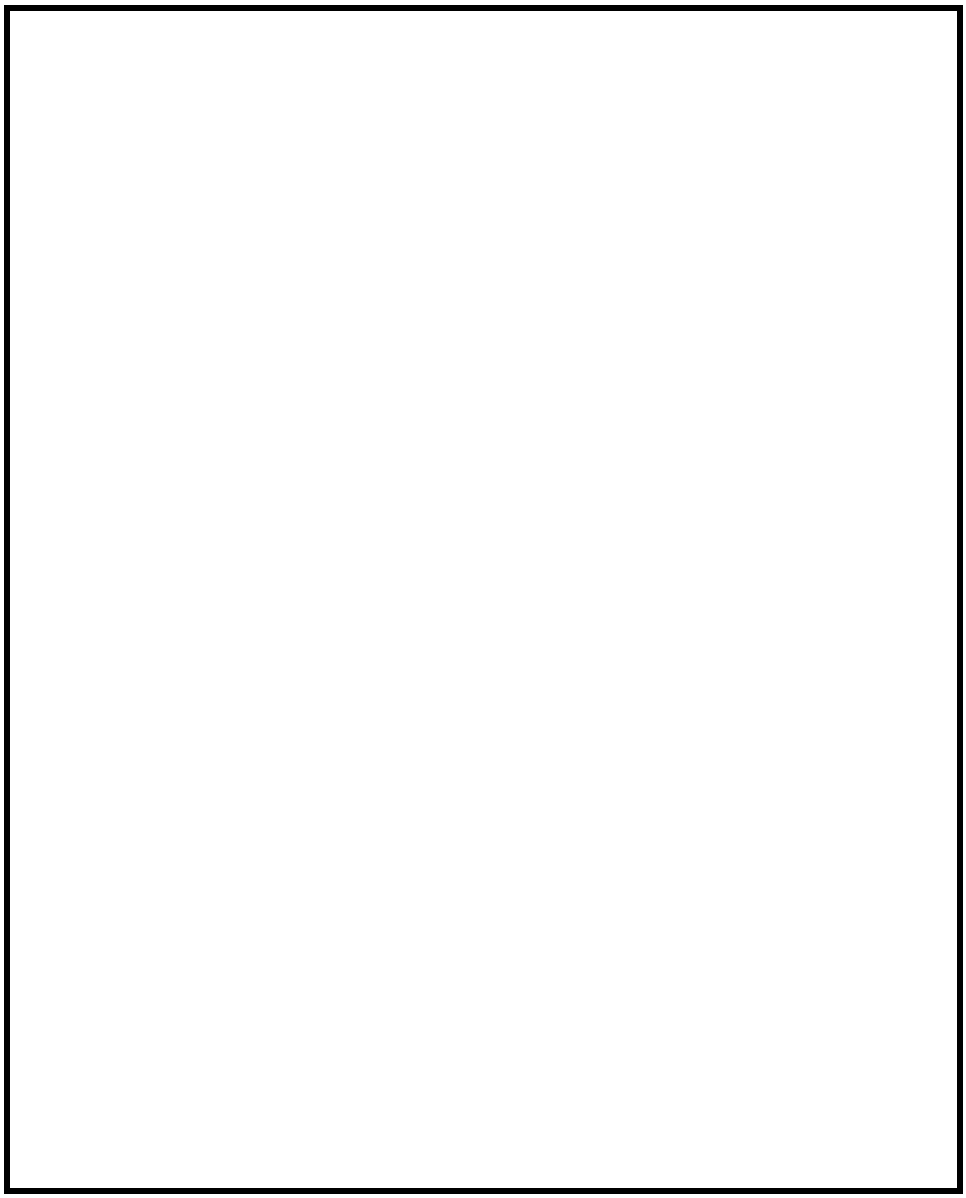


**Figure O-6. M2 machine gun mounted on gun truck**

**O-8. CAMOUFLAGE AND CONCEALMENT**. Camouflage and concealment techniques can be used to make it more difficult for the enemy to spot the convoy. The type of cargo being transported can be disguised or concealed by a tarpaulin. Other effective measures include the following:

- Camouflaging or covering shiny surfaces before convoy departure.
- Painting vehicles in a pattern to blend in with the terrain and break the outline.
- Training operators to look for other means of concealment to break the outline of the vehicle.
- Covering vehicle bumper markings. The vehicle bumper markings can provide a great deal of intelligence information to the enemy.

**Table O-1. Mine test table**

| TEST | RESULTS |
|---|---|
| 12 pounds of C4 under midaxle, right side, exterior tire, top of explosive flush with the ground. | Cargo bed floor was deformed but did not rupture. All bed tie-downs broke except for the two in the front which are spring-loaded. The fuel tank was severely damaged (ruptured) and was thrown away from the vehicle. |
| 12 pounds of C4 under front right tire, 2 inches of soil over the explosive. | The explosion lifted the truck and the front end landed 10 feet away from the initial blast point. Right front panel of the floorboard ripped away from cab walls (12- x 14-inch opening). The cab floor on the blast side near the seat bulged up 3 inches. |
| 12 pounds of C4 under midaxle, left side, interior tire, 2 inches of soil over the explosive. | The explosion lifted the truck and the rear end landed 3 feet away from the initial blast point. Cargo bed floor was deformed and bulged up 2 to 3 inches but did not rupture. Fuel tank ruptured and was thrown 20 feet away from the vehicle. The torso simulator sitting over the midaxle was thrown 10 feet and landed off the cargo bed. The simulator sitting over the rear axle was found still attached to the seat. |
| 12 pounds of C4 under front left tire, top of explosive flush with the ground. | Front left corner of the cab floor separated 6 inches from the cab walls. The cab floor near the driver's seat bulged up 4 inches. Passenger's seat broke in the middle, but torso simulator remained attached to seat. Left front fender and hood were blown away from truck. The explosion lifted the truck and the front end landed 4 feet away from the initial blast point. Floorboard on the right side (blast side) completely ripped open; floorboard on the opposite side separated and lifted 2 to 3 inches. The fire wall near the blast was also damaged. |

**Table O-1. Mine test table (continued)**

| TEST | RESULTS |
|---|---|
| 16 pounds of C4 under front left tire, 2 inches of soil over the explosive. | The explosion lifted the truck and the front end landed 7 feet away from the initial blast point. Floorboard on the blast side ripped away from cab walls 15 inches. Minimal damage to floorboard on opposite side. |
| 16 pounds of C4 under midaxle, right side, interior tire, 2 inches of soil over the explosive. | The explosion lifted the truck and the rear end landed 6 feet away from the initial blast point. The cargo bed completely separated from the chassis and landed sideways several feet away. Both torso simulators, which were sitting in the cargo bed, were thrown 40 to 60 feet away from the truck. |
| 16 pounds of C4 under midaxle, left side, exterior tire, top of explosive flush with the ground. | The explosion lifted the truck and the rear end landed 6 feet away from the initial blast point. Cargo bed floor was deformed and bulged up 4 to 5 inches but did not rupture. Fuel tank ruptured and was thrown away from the truck. Both torso simulators, sitting in the cargo bed, were thrown several feet away from their seats. All cargo bed tie-downs broke. |
| 16 pounds of C4 under front right tire, top of explosive flush with the ground. | The explosion lifted the truck and the front end landed 8 to 9 feet away from the initial blast point. |

**O-9. MINES AND BOOBY TRAPS**. Forces engaging in ambush frequently use mines and booby traps. Command-detonated mines are often used to initiate an ambush. Mines may also be planted along the shoulder of the road to harass and interdict. A booby trap system may be used against personnel and equipment. Convoys have employed the following guidelines to effectively limit damage from mines:

- Track the vehicle in front.
- Avoid driving on the shoulder of the road.
- Whenever possible, do not run over foreign objects on the road.
- Avoid potholes and fresh earth on the road.
- Watch local national traffic and the reactions of people on foot (they will often give away the location of any mines or booby traps).
- When possible, arrange for the engineers to sweep the road ahead before the convoy moves over it.
- Use a 2 1/2-ton or larger truck as the lead vehicle instead of a HMMWV. Hard vehicles such as tanks are useful in exploding small mines in front of the convoy.
- Harden vehicles.

  - Use water in vehicle tires when there is a threat of mines exploding under the tires.
  - Increase ground clearance distance between the point of explosion and the vehicle, if possible.

- Use the following personal safety measures:

  - Wear protective equipment.
  - Use safety belts. Ensure seat belts are tight; otherwise, whiplash may occur during an explosion. Also, fasten the seat belt as low as possible on the stomach.
  - Use correct posture. Keep the backbone straight and supported by a backrest (to better absorb shock) and place feet flat on the floor.

- Slow the vehicle's speed to reduce the potential of accidents. Adjust the speed based on the situation.
- Disperse vehicles and maintain intervals.

NOTE: In Somalia, around Mogadishu, the Army experienced command-detonated mines of 30, 50, and 60 pounds. These devices were placed in one of the many potholes in the road and wired for command-detonation. To avoid such obstacles and/or minimize damage, implement the above techniques.

Some indicators that have proven effective in identifying the location of potential mines are--

- Damaged vehicles.
- Signs of digging, holes in the road, potholes, concrete removal, or puddles.
- Boxes along the roadside.
- Wires on the road surface.
- Evidence of vegetation disturbance.
- Disturbances in previous tire tracks.

- Differences in plant growth, such as wilting or dead foliage.
- Irregularities in color or texture of the ground.
- Signs warning local populace.

The enemy is likely to place mines on--

- Frequently used roadways leading to and from construction sites.
- Brush and other traffic obstructions placed on roadways.
- Bridge bypasses.
- Obvious turnarounds and shoulders.